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HIGH-TEMPERATURE CERAMIC FILTER FOR FURNACE GAS ANALYZER

A. G. Tkachev[1, 2] and O. N. Tkacheva[1]

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The manufacturing of the ceramic filters used in a gas analyzer for sampling flue gases at temperatures to 950°C is described. The proposed technology makes it possible to obtain a through porous structure with pore size varying systematically over the filter wall thickness and thereby obtain a long service life.

Key words: ceramic filter, porosity structure, flue gases.

For a ceramic filter to operate normally the exterior inlet openings of its channels on the filtered medium side must be smaller than on the outlet side. Then the filtered particles remain outside, do not clog the filter over the entire wall thickness and do not make it unserviceable.

For ceramic the question is not one of some linear dimensions but rather the porosity or, more accurately, its structure. It is obvious that the condition formulated can be met if the size of the communicating pores forming a system of channels will increase over the cross section of the filter wall in a direction from the outer to the inner surface. Thus, the problem of developing a technology for obtaining a ceramic filter with an extended service life reduced to finding methods and devices for forming ceramics with a prescribed pore-size distribution over the wall thickness.

The simplest and widely used methods of creating and regulating porosity were used to solve this problem — the insertion of burnable additives and adjustment of the particle-fraction composition of the filter body [1, 2] but with very important features. These features can be realized provided that the filter body is formed by slip casting in a gypsum mold.

The crux of the proposed method of obtaining a ceramic filter with porosity varying over the thickness of the filter wall reduces to the following. The casting slip must contain fine, medium and coarse particles, and the number of intermediate size particles must be much smaller. The purpose of the medium particles is to create a rigid porous framework, and for this reason they must not give dry or fire shrinkage. The best material for this is chamotte made from fireclay. The purpose of the fine particles is to create a fine-porous exterior surface layer on the filtered-medium side.

When clay or kaolin is used for the fine fraction their particles are located in the gaps of the rough chamotte framework and as clay fragments start to accumulate they form a practically pore-free structure. However, on drying or firing this plastic filler in a rigid framework shrinks and porosity due to shrinkage cracks appears. The magnitude of this porosity can be regulated within very appreciable limits. Thus, the more refractory and less plastic kaolin will give less fracturing compared with refractory clay and vice versa. A change of the firing temperature other conditions remaining unchanged can also be used for changing the width of the shrinkage cracks by means of the degree of sintering.

If the ceramic part is formed by slip casting, the size of the large particles is limited because of possible sedimentation. For this reason, however, if comparatively large pores are required, it is not enough to adjust the size fraction and a burnable additive of the same size as the coarse fraction of chamotte must be introduced. In addition to the components listed above the slip can also contain a ready glass phase for intensifying liquid-phase sintering and imparting due to this strength to the clay fragments as well as liquefier electrolytes for regulating the rheological properties.

On this basis the mechanism of filter formation can be represented by the diagram shown in Fig. 1. After the slip has been poured, because the gypsum mold initially absorbs water, particles of all fractions will move toward its surface. After some time a layer of stationary particles, which have come into contact with one another — the coarse particles being the main ones, forms on the surface of the mold. How-

[1] Southern-Russia State Technical University, Novocherkassk, Russia.
[2] E-mail: tkach.ru1950@yandex.ru.

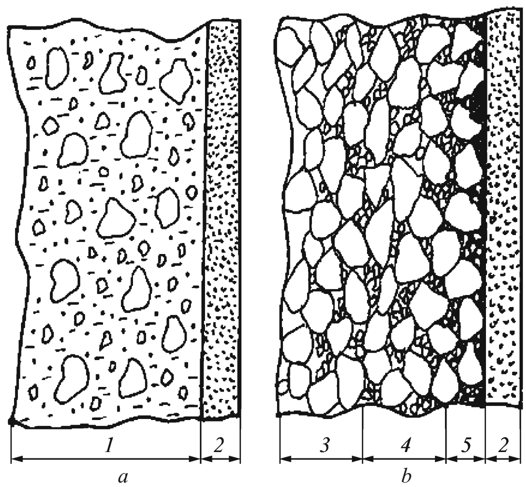

Fig. 1. Slip – gypsum mold system: *a*) before clay fragments start to accumulate; *b*) post-accumulation; *1*) casting slip with suspended particles of the fine, medium and coarse fractions; *2*) gypsum mold; *3*, *4*, *5*) coarse, medium and fine porous zones of the filter wall formed, respectively.

ever, the slip continues to move toward the mold but now along the gaps of the coarse-pore framework which has appeared. It is evident that the fine particles have the best possibilities for advancing along the surface of the mold, which is what happens in practice. The larger, medium size particles cannot reach the surface of the mold, i.e., they stop at some distance from it.

A very important condition must be satisfied in order to attain variable porosity in this scheme. The amount of the fine fraction must be sufficient but no more than that required for a comparatively thin surface layer to form. For the same reasons the amount of the medium fraction intended for creating a deeper, subsurface layer must also be limited.

Ultimately, when the indicated condition is satisfied the formation of the wall proceeds in several stages. First, a framework layer is formed from the coarse particles; second, the slip containing medium and fine fractions percolates through this framework, the fine fraction passing to the surface of the gypsum mold and forming together with the other fractions a thin surface layer. The medium fraction is held back first and forms together with the coarse fraction a thicker, more porous layer.

As a result the medium and fine particles present in the slip in small amounts leave the slip and at the final stage a third interior layer consisting predominately of the remaining coarse particles of chamotte and burnable additive is formed. This separation of the formation process is quite arbitrary. In practice no clear boundaries are observed between these stages, rather there is a smooth transition from one to another but with the regularities indicated above holding over all.

The mechanism of formation of the filter body described above presupposes a very low content of the fine fraction, consisting of plastic materials. Their amount in the raw material mix is too low to separate the casting from the gypsum mold.

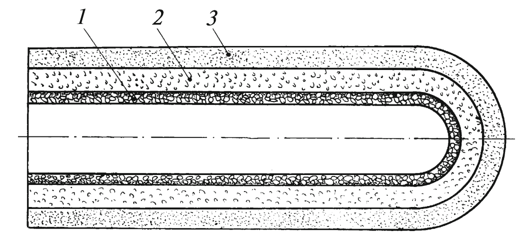

Fig. 2. Filter fragments in the ceramic cage: *1*) intermediate filter product; *2*) gypsum mold; *3*) ceramic cage.

For this reason, for the present case we developed a special casting technology. In this technology the casting gypsum mold is used not as a separate element but rather in the form of an internal gypsum layer deposited on the specially fabricated ceramic base – the cage (Fig. 2). In this case, after the casting of the intermediate product is formed it is dried and then fired together with the cage and gypsum layer at 900°C. After firing at this temperature the casting is strong enough for further processes, the gypsum layer breaks down and the products of decomposition essentially form no compounds with the intermediate product. After the first firing the filter to be is easily extracted from the ceramic cage, cleaned of remaining CaO particles and subjected final firing at 1130°C. After being cleaned of residues of the decomposed gypsum the ceramic cage can be reused.

It was determined that to satisfy this requirement the slip particle-size must be as follows, mm: average fraction 0.1 – 0.2; coarse 0.5 – 0.6; glass phase (glaze frit) no more than 0.063 with residue on No. 0063 sieve no more than 2%. The slip composition (wt.%) is: chamotte coarse fraction — 55; medium — 8; coal — 19; kaolin (fine fraction) — 4; earthernware glaze frit — 14; > 100%: refractory clay — 3; soda ash — 0.3; liquid sodium glass — 0.4; moisture content 45 – 52%. In this case the clay is concurrently a component and suspending additive.

When necessary this technology can be used to fabricate ceramic high-temperature filters not only with cylindrical but also other shapes. Their porosity is regulated over a considerable size range and fraction ratios as well as second firing temperature.

REFERENCES

1. A. G. Tkachev and O. N. Tkacheva, "Technology of making ceramic articles with a prescribed through porosity structure," in: *Abstracts of Reports at the Scientific-Technical Conference on Science and Technology of Silicate Materials in a Market Economy* [in Russian], Southern-Russia State University (NPI), YURGTU (NPI), Novocherkassk (1999), p. 24.
2. A. G. Tkachev, V. A. Guzii, and O. N. Tkacheva, "Ceramic flame suppressor," *Steklo Keram.*, No. 11, 16 – 17 (2001); A. G. Tkachev, V. A. Guzii, and O. N. Tkacheva, "Ceramic flame damper," *Glass Ceram.*, **58**(11 – 12), 394 – 395 (2001).